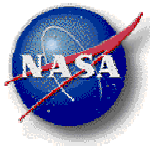
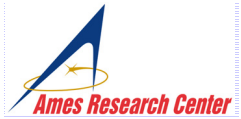


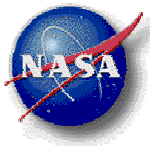
Concept Portrayal Response: The Developers Turn

Kevin James

NASA Ames Research Center

August 27, 2002





Outline

- 3-5 Minutes Position Clarification by each of the Principle Investigators
- General Discussion to follow, given any remaining time

VAMS

Ames Research Center

Terminal Area Capacity Enhancement Concept

TACEC

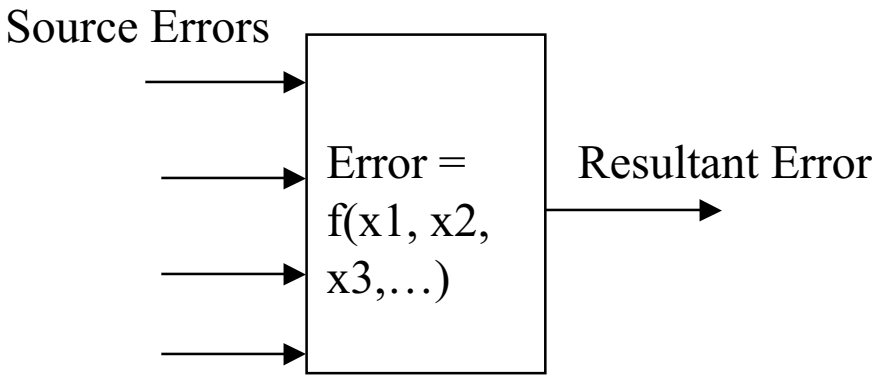
Modeling Requirements

August 22, 2002

Modeling Approach

Raytheon
C³I / C³S

- **Start with lowest-level fidelity model of all functions needed to evaluate concept**
  - **Breadth vs Depth**
  - **Increase fidelity in later phases as evaluation warrants**
  - **Model effects of the enabling technology. For example, WAAS resultant position/velocity errors instead of explicit models of GPS Constellation, Ground Stations, Avionics, etc**
  - **Include primary error contributors**
    - **Errors may be initially constant (but tuneable) and then dependent upon current condition (weather, flight geometry, etc) as simulation matures**



Evaluation requires Realism

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- **Perfect CNS and FMS**
  - Aircraft Truth State (ATS) = Commanded Flight Path (CFP)
- **Simulation must include realistic errors of enabling CNS and FMS technologies to evaluate concept feasibility**
  1) Add FMS errors (ability to maintain flight path)
     - » ATS = CFP + FMS Flight Path Deviation
  2) Add Navigation/Tracking errors (knowledge of own aircraft position)
     - » Aircraft Sensed State (ASS) = ATS + Tracking Errors
  3) Add Surveillance/Comm errors (reporting of own aircraft position)
     - » Aircraft Reported State (ARS) = ASS + Reporting Errors

FMS Error Model

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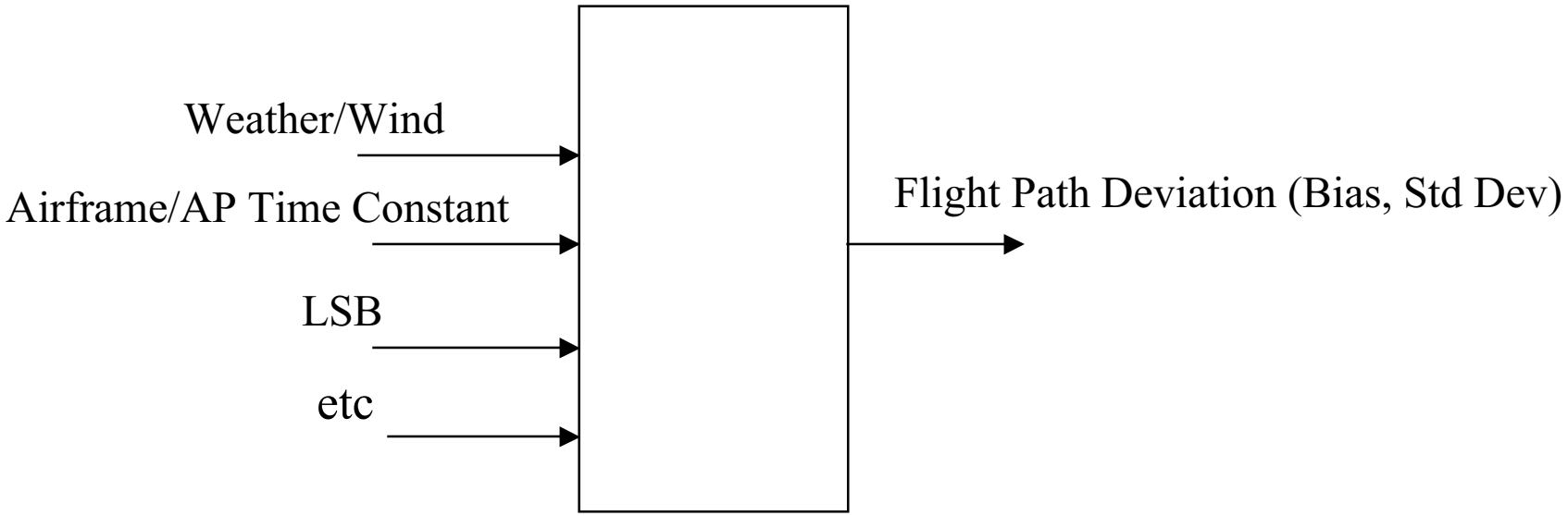
1) Ability to maintain commanded flight/surface path

- **Add Flight Path Deviation to Commanded path to generate Aircraft Truth State**



Navigation/Tracking Error Model

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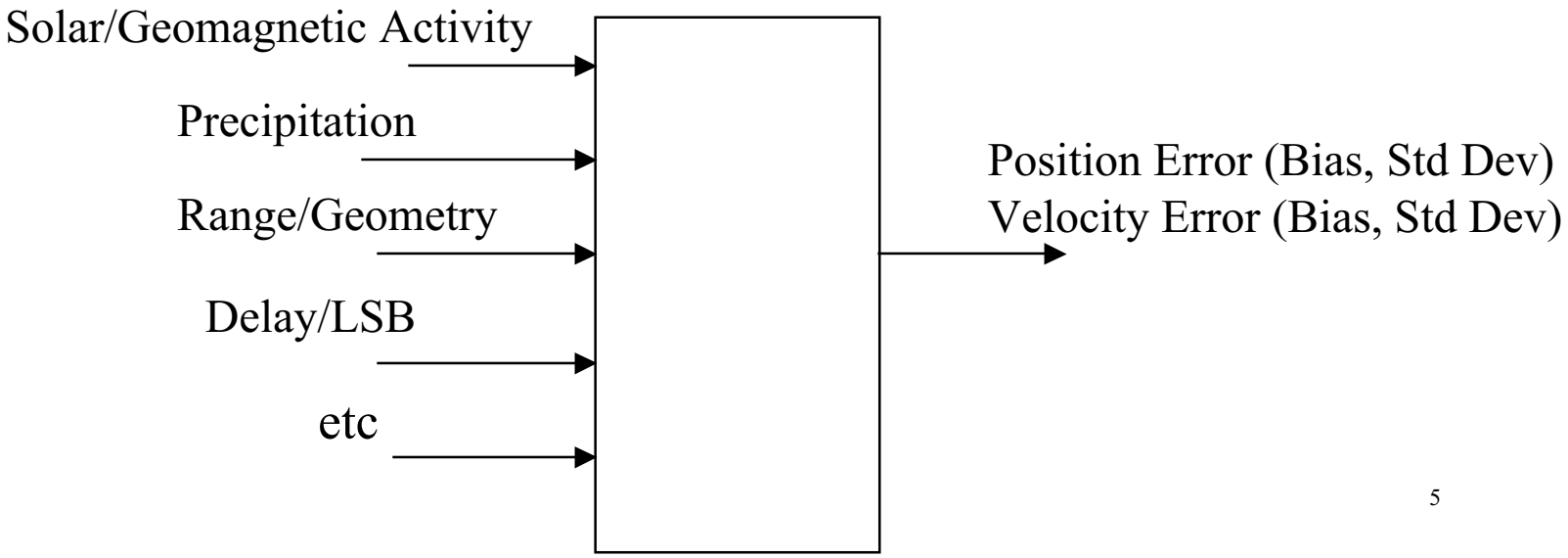
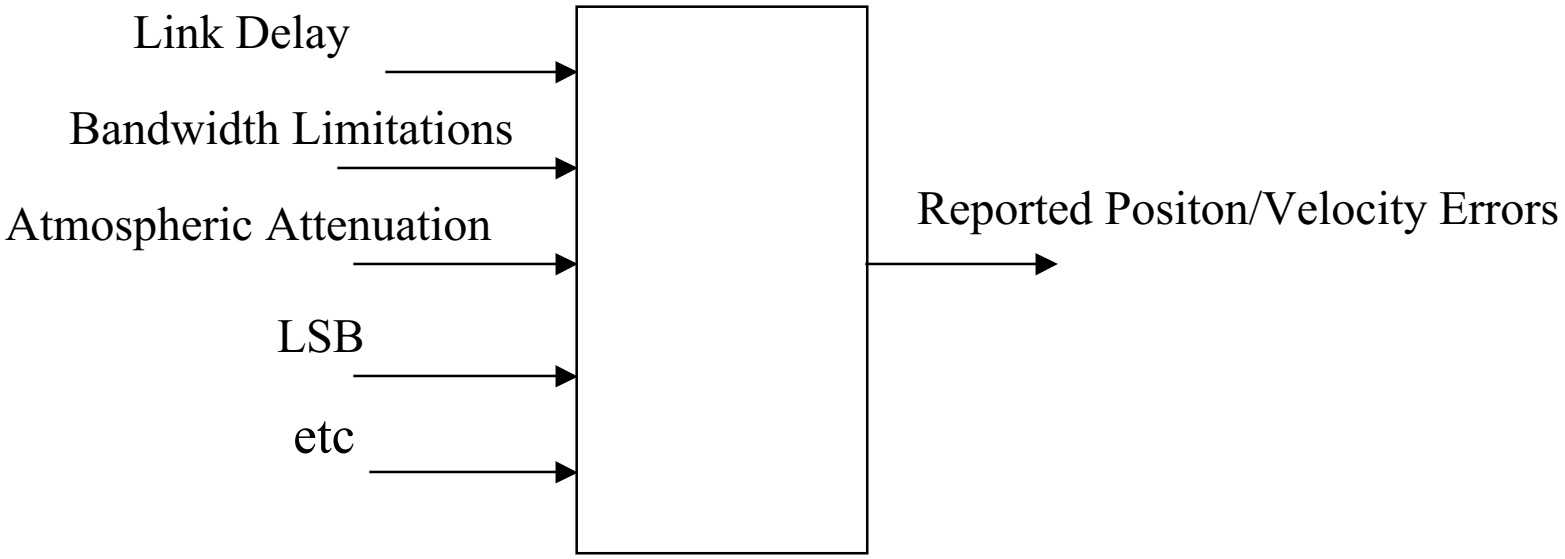
2) Knowledge of own aircraft position via selected technology (GPS/WAAS, GPS/LAAS, ILS, Primary Radar, ASDE-X, etc)

- » **Include Noise and Bias Errors with values based on selected tracking technology**
- » **Add Resultant Tracking Errors to Aircraft Truth State**



Surveillance/Comm Error Model

3) Reporting position of own Aircraft to Ground Controllers and/or other Aircraft via selected technology (ADS-B, Mode 6)



Ground-based Operational Algorithm Models

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- **TACEC Operational Algorithms to be included in simulation**
  - **Terminal Airspace**
    - » **4D Curvilinear Flight Path w/Wake Vortex & Weather Avoidance**
  - **Surface**
    - » **Runway/Taxiway Optimal Path**

- **Inputs to Operational Algorithms, with increased fidelity as simulation matures**
  - **SLIC Phase 2 requires low fidelity models of**
    - » **Reported Aircraft State, Wake Vortex, Wind, Convective Weather, Surface/Gate Status**

Ground/Air Collaboration

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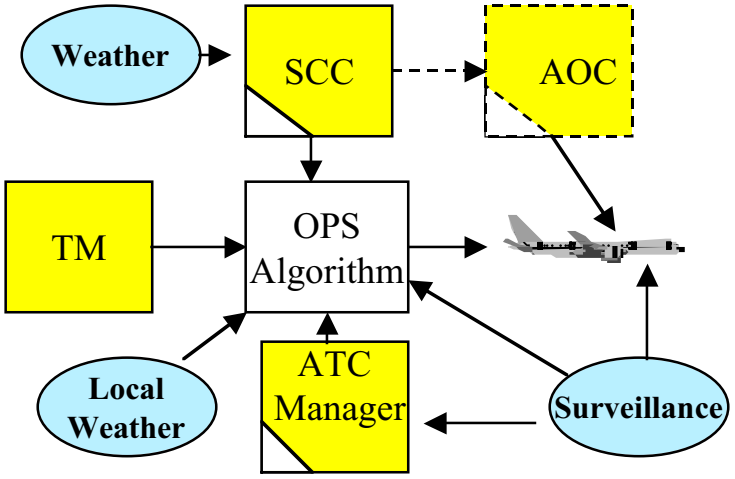
- **Model of ground manager/flight crew interfaces needed to evaluate flight path collaboration, separation, and conflict avoidance advisories**
- **TACEC requires low fidelity models of functional elements and data links depicted below in SLIC Phase 2**



Surface Environment

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- **Model of Airport Infrastructure and Integrated Terminal Area Network needed to evaluate Surface Automation**
  - **Initially leaning toward an Analytical Model of the Surface Environment**
    - » **Parameters such as aircraft type, arrival/departure speed, arrival/departure runway occupancy time, position uncertainty, wind speed, communication delay, passenger load/unload, pre-trip security, gate availability, de-icing, etc will need to be included**
    - » **If further analysis indicates an Analytical Model will not satisfy evaluation, a true simulated model with detailed representation of airport infrastructure and operations will be required**

Wake Vortex Model

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- As a primary constraint on Arrival Rate, Wake Vortex (WV) is needed to evaluate Terminal concepts
- SLIC Phase 2, WV may be modeled as a constant (tuneable) dimension around a point source aircraft based on existing WV separation requirements
  - 4D Trajectory Algorithm based on constant separation
- SLIC Phase 3, include WV movement due to wind
  - Include Wake Vortex Advisory System effects by adding errors on actual WV position. 4D Trajectory Algorithm uses predicted WV position.

Weather Model

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- Weather phenomenon impacting air transportation include, winds, turbulence, thunderstorms, hail, micro bursts, downdrafts, fog, and ice

- TACEC requires in SLIC Phase 2

  - » Atmospheric Winds to evaluate flight path control
  - » Convective weather to evaluate weather avoidance

  – Additional models in SLIC Phase 3

  - » Ice and Fog to evaluate effects on surface ops

- Weather Forecast data needed by ground managers and flight crew

Noise/Pollution Model

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- **Noise is a primary constraint on Airport Capacity**
  - **TACEC requires in SLIC Phase 2 a noise model such as Metron's Noise Impact Routing System (NIRS) to evaluate terminal flight paths**
- **Aircraft emissions have a significant impact on environment**
  - **TACEC requires an emissions model in SLIC Phase 3 to evaluate arrival/departure and surface procedures that will save fuel and reduce emissions**

Recommended PTP Primary Components for VAST Modeling

- Door-to-door (e.g., multi-modal modeling)
- Small airport automation
- Terminal airspace design/impacts (utilizing the 5400+ airports)
- Increased flight network connectivity (e.g., greater use of PTP vs. HS)
- Conflict free (aircraft, Wx, wakes) 4D precision trajectories
- DSTs (optimal trajectory planning, CDM, TFM, AOC Precision Control Toolbox)
- Dynamic sectors & sectorless flight levels
- Self-separation
- Mixed equipage
- CNS (ADS-B, FMS, TIS-B, CPDLC, LAAS, WAAS)

PTP VAST Modeling Unique Needs/Issues

- **Door-to-door (e.g., multi-modal modeling)**
  - Primary impact for the cost model
- **Small airport automation**
  - Cost models need to address life cycle costs of non-towered sensors and ground automation and new avionics
  - What will be the allowed throughput?
- **Terminal airspace design/impacts**
  - Analysis is required to optimize each terminal area (i.e. they are all unique!)
  - Terminal land features are fixed, e.g. runway location, relative location to other airports
  - Need to take into account local (i.e., not just itinerant) traffic operations as loading on smaller airports.
- **Increased flight network connectivity (e.g., greater use of PTP vs. HS)**
  - 5400+ airports with a network to each other (e.g. no dog legs).
- **Precision Control Toolbox**
  - Provides AOC the ability to adjust arrival times
- **DSTs (optimal trajectory planning, AOC Collaboration)**
  - AOC has pre flight objectives as well as in flight. AOC will negotiate with ATSP for optimal/neighboring optimal trajectory.
- **Dynamic and Sectorless airspace**
  - New sectorless airspace, centralized monitoring, operational impacts
  - Dynamic based upon workload (accounts for complexity)

General VAST Modeling Issues

- **All concepts (not just PTP) need higher 2020 traffic level-based demand with expected fleet mix changes (e.g., greater frequency of smaller commuter/air taxi flights)**

- **Lots of Concept PTP functions exist (some overlapping with other concepts); how to deal with overlap between aspects of our concept and others?; blending sooner or later?**

- **Need to get VAST functionality with deep enough level of fidelity to represent details of new concept focus (e.g., anchor points); tradeoff of fidelity with scope**

	Concept Developer	Raytheon					
	SLIC Phase		2	3	4A	4B	See Slide
GFI Model	**VAMS Required Functionality**						
Nat Traffic Mgmt	"5400 Airport" System Model						
	Full Trajectory Conflict Avoidance						
	High/Low Density Regions						
	On-Demand Ops						
	Sector and Sectorless Ops						
	Sequential Trajectory Planning						
	Weather Avoidance Algorithms						
Local Traff Mgmt	4D Terminal Path Alg - groundbased	x	L	M	H		7
	ATSP/Weather Displays						
	Blunder Reconginition Time						
	Curvilinear final flight paths	x	L	M			7
	New Decision Support Tools	x	L	M	H		
	Surface Automation	x	L	M	H		7, 9
	Surface Automation via Controllers						
	Surface Automation via FMS	x	L	M	H		7,9
	Surface Automation via lights						
	Surface Automation via Pilots						
	Surface Automation via timed routes						
	Surface Deceleration Control Alg.	x	L	M	H		7,9
	TCAS						
	Terminal FP Alg. Monitored by Specialist						
	Tower Monitors/Surface Displays	x			L		
	TSAFE						
	Wake Vortex Avoidance Alg.	x	L	M	H		7,10
	Weather Avoidance Algorithms	x	L	M	H		7,11
	Wind Optimal Routing	x		L			
	Workload - Controller	x		L	M		
CD&R & SA	Full Trajectory Conflict Avoidance	x	L	M	H		8
	Surface						
Flight Plan/Collab	Collaborative Flight Planning	x	L	M	H		8
	Collaborative Arrival/Departure	x	L	M	H		8
Traff Cont & Adv	Conflict Avoidance Advisories	x	L	M	H		8
	Override to FlightPath by ATC	x	L	M	H		8
	Separation Assurance Advisories	x	L	M	H		8
Adj Air Traff Fac							
CNS/Weather							

	Concept Developer	Raytheon					
Communication	Generic Surv/Comm Errors		L	M			6
	VHF/UHF Datalink	x		L	M	H	
	UHF/VHF - Voice Comms						
	NEXCOM Digital Radio						
	Integrated Terminal Area Network	x	L	M	H		
	Increased VHF Safety						
	NASWIS						
Navigation	Generic Nav/Tracking Errors		L	M			5
	GPS Constellation/Surv Errors	x	I	L		M	
	GPS Redundant Ground System						
	LAAS	x	I				
	GPS (see above)						
	Correction Algorithms/Msg Content			L			
	VHF Datalink (see above)						
	Ground-based Transmitter						
	Atmospheric Attenuation (see above)						
	Aircraft Avionics (see Airframe below)						
	WAAS	x	I				
	GPS (see above)						
	Wide Area Ground Reference Stations			I			
	Wide Area Master Stations/Processing			L			
	Correction Message			L			
	Ground Uplink Station			I			
	GEO Satellites			L		M	
	Aircraft Avionics (see Airframe below)						
	Atmospheric Attenuation (see above)						
	ILS						
Surveillance	Generic Surv/Comm Error	x	L	M			6
	ADS-B	x	I	L		M	
	GPS (see above)						
	1090ES datalink (commercial aviation)			L		M	
	UAT link (general aviation)			L		M	
	1Hz surv - reduced sep via ATC			L			
	Air/Air surv & alerting - self sep			L	M		
	Flight path intent, low fuel alert, etc			L			
	Atmospheric Attenuation		I	L		M	
	Aircraft Avionics (see Airframe below)						
	ASDE-X	x	I	L	M	H	
	Radar/Surv Errors		I	L		M	
	Collision Alert/AMASS		L	M	H		
	Mode-S	x	I				
	Surveillance radar (beacon)			L		M	
	Aircraft Transponder			L		M	
	Ground-based signal processing			L			
	Digital Datalink - air-to-air			L		M	

	Concept Developer	Raytheon					
	Digital Datalink - ground-air-ground			L		M	
	Message Content (incl weather?)			L	M	H	
	Cockpit Display (CDTI? - see Airframe)						
	Atmospheric Attenuation (see above)						
	Multi-sensor Surface Surveillance fusion	x					
Weather	Stochastic Weather						
	Wake Vortex	x	L	M	H		10
	Weather	x	L	M	H		11
	Weather Exposure						
	Weather Sensing/Prediction	x	L	M	H		11
	ITWS, Enroute?						
Aircraft Control	4D FMS Terminal	x	L	M	H		4
	Aircraft Self Separation	x	L	M	H		8
	Missed Approaches	x		L	M	H	
	Override to Terminal Flightpath by Pilot	x		L	M	H	
	Workload - Crew	x		L	M	H	
Airframe	FD/Weather Displays						
	FMS/Datalink/CDTI Equipped Aircraft	x	I	L		M	4,6
	Smaller/Varied Aircraft						
Land/Intermod	Door-to-Door Transportation						
	Street-side	x	L	M	H		9
Term Cargo/Sec	Passenger Load/Unload						
	Pre-trip Security						
Airspace	Modified Enroute Sectors						
	Modified TMA						
	Modified TRACON	x	L	M	H		
	Tube Concept						
Rules/Proc/Stnds	Separation Standards	x	L	M	H		
AP Runways, etc	Airport Lighting						
	Average Queuing Time (surface)	x	L	M	H		9
	De-Icing	x		M	H		9,11
	Gate Availability	x	L	M	H		9
	Gate Maintenance						
	Non-Towered Airport ATM						
	Ramp	x	L	M	H		9
	Runway Configuration	x	L	M	H		9
	Runway Incursions	x	L	M	H		9
	Runway Occupancy	x	L	M	H		9

	Concept Developer	Raytheon					
	Runway Occupancy Charge						
	Small/Regional Airports						
	Surface Congestion	x	L	M	H		9
	Taxi-in Time	x	L	M	H		9
	Taxi-out Time	x	L	M	H		9
NAS Mgmt	Airspace Auctioned						
	Traffic Demand Model for 2020						
Design Consid.	Cost - Direct Operating	x	L			M	
	Cost - Provider, System, User	x	L			M	
	Cost - Terminal Area	x	L			M	
	Noise	x	L	M	H		12
	Pollution	x		L	M	H	12
	Stochastic SUA						
AOC	Optimal Origin/Destination Flight Paths	x	L	M	H		